FUGRO CONSULTANTS, INC.

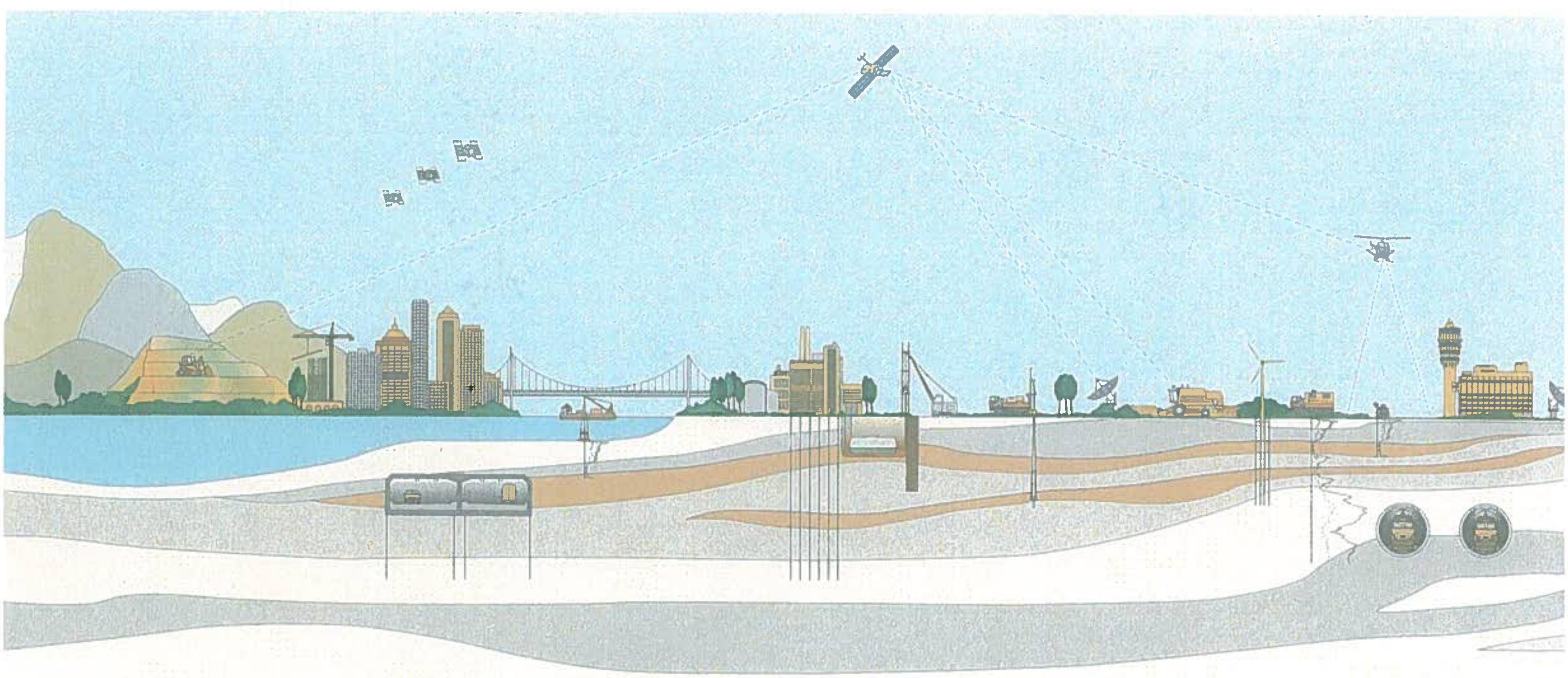
GEOTECHNICAL INVESTIGATION
CROSSCUT CANAL MULTI-USE PATH PHASE II
CANAL PARK TO MOEUR PARK
TEMPE, ARIZONA

City of Tempe Project No. 6002441 and Encumbrance No. 8123733

Prepared For

CITY OF TEMPE
TEMPE, ARIZONA

December 18, 2008



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Public Works / Engineering
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Report No. 3808-1014
December 18, 2008

Attention: Mr. Kent Clayton, E.I.T.

Geotechnical Investigation
Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
City of Tempe Project No. 6002441 and Encumbrance No. 8123733
Tempe, Arizona

Submitted herewith is the report of the geotechnical investigation conducted for the above referenced project. In brief, the report contains a plan of borings, boring logs with laboratory test results and descriptions of subsurface conditions. Based on the findings, recommendations are set forth for design and construction of the bridge foundations and concrete multi-use path.

Fugro Consultants, Inc. appreciates the opportunity to provide these geotechnical engineering services for the City of Tempe. We look forward to future assignments.

Sincerely,
FUGRO CONSULTANTS, INC.

Jaime Reyes, Jr.

Jaime Reyes, E.I.T.
Graduate Engineer

Thomas C. Wesling

Thomas C. Wesling, P.E.
Arizona Operations Manager

Registered Professional Engineer (Civil)
CERTIFICATE NO. 40730
THOMAS C. WESLING
Date Signed 12-18-08
ARIZONA, U.S.A.

TCW(g\2008\projects\3808-1014 Crosscut Canal Multi-Use Path\R3808-1014)
Attachments
Distribution:
City of Tempe, Mr. Kent Clayton, E.I.T. (4 bound, 1 pdf)
File (1 bound, 1 unbound, 1 pdf)

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INTRODUCTION

On December 1, 2008, Fugro Consultants, Inc. initiated a geotechnical investigation for the proposed bridges and multi-use path that will be constructed from Canal Park to Moeur Park in Tempe, Arizona. The approximate location of the site is shown on the Vicinity Map, Plate 1.

AUTHORIZATION

The project was authorized via City of Tempe Contract for Professional Services (Contract No. C2008-235) dated November 20, 2008. Fugro's proposal No. P08-1026 dated October 16, 2008 outlines the scope of services for the investigation.

PURPOSE AND SCOPE

The purpose of the investigation was to 1) obtain adequate subsurface information to identify geotechnical and geologic conditions at the boring locations; 2) provide geotechnical recommendations for design and construction of drilled shafts for the bridge abutments; 3) provide earthwork recommendations for the subgrade and potential fill beneath the concrete multi-use path; and 4) to provide discussions regarding corrosion potential of on-site soils, excavation potential and localized stable cut slopes.

This was accomplished through a three phase study including 1) a field investigation for determining general subsurface conditions at the boring locations and obtaining representative samples for classification and testing; 2) a laboratory testing program to aid in soil classification and to establish engineering properties of the strata encountered; and 3) analyses of field and laboratory data to develop geotechnical design and construction recommendations.

Field sampling, laboratory testing, soil classifications, and strata descriptions were in general accordance with methods, procedures, and practices set forth by the American Society for Testing and Materials, 2007 Annual Book of ASTM Standards, where applicable.

FIELD INVESTIGATION

The field investigation consisted of twelve borings, which are listed in the following table along with the approximate location of the boring and the boring depth. The approximate boring locations are also shown on the Plans of Borings, Plates 2a through 2h. The longitude and latitude of each boring was obtained with a hand held global positioning unit and are provided on the bottom of each boring log. The approximate ground surface elevation at each boring is provided at the top of the boring logs, and was interpolated from the topographic information on the plans provided.

Boring	Approximate Boring Location	Boring Depth (ft)
B-1	South Abutment of South Bridge near Sta. 11+10	35.5
B-2	South Abutment of South Bridge near Sta. 11+60	26.0
B-3	Pedestrian Node near Sta. 19+50	10.5
B-4	West Abutment of Middle Bridge near Sta. 27+90	21.5
B-5	East Abutment of Middle Bridge near Sta. 28+30	25.0
B-6	Path near Sta. 33+20 (zigzag section off main path)	10.5
B-7	Path near Sta. 38+20 (5-ft vertical cut area)	10.5
B-8	Path near Sta. 40+70	5.0
B-9	Path near Sta. 43+80	4.5
B-10	Path near Sta. 49+00 (8-ft vertical cut area)	10.5
B-11	East Abutment of North Bridge near Sta. 65+90	40.5
B-12	West Abutment of North Bridge near Sta. 67+00	40.5

Detailed descriptions of subsurface materials encountered at each boring location are presented on the Logs of Borings, Plates 3 through 14. Observations of groundwater made during drilling are presented at the bottom of the boring logs. The Keys to Terms and Symbols used on the logs are presented on Plates 15 and 16.

The borings were advanced through the on-site soils with a truck-mounted drill rig using 7-inch diameter hollow stem augers. Samples of the subsurface materials encountered at the boring locations were obtained with a 2.0-inch standard split spoon sampler (ASTM D 1586) in general accordance with the referenced ASTM procedure. The number of blows required to advance the sampler was recorded as the penetration resistance (SPT or N) value. Depths at which the samples were obtained and the penetration resistance values are shown on the boring logs. At the borings B-4 and B-5 locations, after auger refusal was encountered, the borings were advanced using core drilling procedures (ASTM D 2113) to their completion depths with a 2.4-inch inside diameter core barrel. The borings were backfilled with auger cuttings upon completion of drilling activities.

LABORATORY TESTING

The laboratory testing program included identification and classification testing of the strata encountered in the subsurface. Soil classification tests, including Atterberg limit determinations (ASTM D 4318) and partial grain-size analyses (ASTM D 422) were conducted on representative samples of the soil strata. Unconfined compressive strength (ASTM D 2938) tests were performed on selected intact rock cores. The water contents, Atteberg limits, percent passing the No. 4 and 200 sieves, and the unit dry weights of the rock cores are tabulated on the boring logs under the appropriate columns. Results of the full sieve analyses are presented on Plates 17 through 21.

The laboratory testing program also included natural pH, soluble chloride, soluble sulfate, and resistivity tests. A summary of the analytical laboratory test results is presented in the following table.

Boring Number	Sample Depth (feet)	PH	Electrical Resistivity (ohm-cm)	Soluble Chloride Content (ppm)	Soluble Sulfate Content (ppm)
B-2	0 to 3	8.0	268	960	530
B-5	0 to 2	7.9	134	500	260
B-11	0 to 2	8.3	736	310	93

STRATA DESCRIPTIONS

Descriptions of strata made in the field at the time the borings were drilled were modified in accordance with results of laboratory tests and visual examination. All recovered soil samples were classified in general accordance with ASTM D 2487 and described as recommended in ASTM D 2488. Rock strata were classified in general accordance with "Rock Classification and Description," Chapter 1, Section 5, NAVFAC DM-7.[1] Classifications of the soils and finalized descriptions of both rock and soil strata are shown on the logs of borings.

SUBSURFACE CONDITIONS

Geology

According to the Geologic Map of Arizona[2] and the Geologic Highway Map of Arizona[3], the site is underlain by Granitic Rocks. This mapped unit consists of a wide variety of granitic rocks; biotite granite with large feldspar crystals common.

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1 U. S. Navy (1971), Design Manual-Soil Mechanics, Foundations and Earth Structures, NAVFAC DM-7.
2 Richard, S.M., Reynolds, S.J., Spencer, J.E. and Pearthree, P.A., Arizona Geological Survey, Map 35, 2000.
3 Map Editors: Kamilli, R.J., and Richard, S.M.Arizona Geologic Society and Arizona Geological Survey, 1998.

Site Stratigraphy and Engineering Properties

Subsurface conditions at the site can be best understood by a thorough review of the boring logs presented on Plates 3 through 14. A brief summary of the subsurface conditions encountered at the boring locations is presented in the following paragraph.

The site is primarily underlain by completely weathered granite (sand and gravel with varying amounts of silt and clay). The soils encountered have measured water contents ranging from 1 to 8 percent (average 4 percent), plasticity indices vary from non-plastic to 17 (average 8), percentages of material retained on the No. 4 sieve range from 13 to 51 (average 33), and percentages of material passing the No. 200 sieve range from 10 to 33 (average 22). Standard penetration test (SPT) values varied from 12 blows per foot (bpf) to refusal.

At the boring B-4 and B-5 locations, moderately to highly weathered granite was encountered at depths of 3 ft and 10 ft, and was cored to the boring completion depths of 21.5 and 25.0 feet, respectively. Core recovery values varied from 0 to 100 percent and Rock Quality Designation (RQD) values varied from 0 to 83 percent. The measured dry unit weights of granite cores were 156, 153, 155, 153, and 155 pcf. Measured unconfined compressive strength values of the granite cores were 445, 177, 346, 163 and 222 tsf.

Groundwater

Groundwater was not encountered in any of the borings at the time of drilling. It is anticipated that groundwater will likely be encountered due to the adjacent running water source.

GEOLOGIC HAZARDS

The following sections describe potential geologic hazards at the site, including land subsidence and earth fissures, and faulting and seismicity.

Land Subsidence and Earth Fissures

Earth fissures occur in southern Arizona in areas of groundwater depletion. Earth fissures generally occur on the periphery of land subsidence areas. Based on our review of documented earth fissures[4], there are no known fissures underlying the project site. However, the site is located in an area that is mapped as having groundwater depletion in the range of 100 to 300 feet. The nearest earth fissure zones to this site are about 13 miles north and 17 miles

[4] Schumann, H.H. and Genualdi, R.B., Land Subsidence, Earth Fissures and Water Level Changes in Southern Arizona: Arizona Geological Survey Map 23, 1986.

east. Earth fissures may extend and new earth fissures could form due to continued groundwater pumping and land subsidence in the Valley.

Faulting and Seismicity

According to the "Map of Quaternary Faults and Folds of Arizona" prepared by the Arizona Geological Survey Open-File Report 98-24 there are no known active faults underlying the project site or adjacent areas. The nearest fault zones are Horseshoe Fault Zone and Carefree Fault Zone about 30 miles northeast and 20 miles north, respectively. Based on Seismic Contour Acceleration Maps for Arizona issued with Report Number AZ92-344 by ADOT in September of 1992, the site is located in a zone where the peak ground accelerations at bedrock that have a 90 percent probability of non-exceedance in 50 years is 0.03g.

STRUCTURAL DETAILS

Based on information obtained from the project plans provide by the City of Tempe, the south, middle and north bridges will have span lengths of about 30, 30 and 80 ft, respectively. According to information provided by Mr. William Rodriguez of T.Y. Lin International the approximate load (dead and live) on each shaft at the south, middle and north bridges is 78, 75 and 150 kips, respectively. The proposed concrete multi-use path will be accessible in accordance with the American Disability Act (ADA). The concrete section will be 6-inches thick and 10-feet wide, and extend from Canal Park to Moeur Park.

BRIDGE FOUNDATION ANALYSIS AND RECOMMENDATIONS

Analysis of the field and laboratory data indicates that subsoils at the site are suitable for support of the proposed bridges on straight sided drilled shafts. Recommendations are provided in the following sections for straight sided drilled shaft design, straight sided drilled shaft construction, and seismic site class.

Straight Sided Drilled Shaft Design

1. **North and South Bridges.** Axial capacities for single drilled shafts are presented on Plate 22 for the north and south bridge foundations. Capacity curves are provided for shaft diameters ranging from 2 to 5 feet in six-inch increments. Drilled shaft lengths should not be less than 20 feet below abutments for the proposed north and south bridges. Drilled shaft diameters should be at least 24 inches.

   Middle Bridge. Drilled shafts for the proposed middle bridge should penetrate the moderately to highly weathered granite a minimum of 5 feet and be designed using an allowable end bearing of 20 ksf. The shaft tip elevations should be below elevations

1,218 ft and 1,212 ft for the west (B-4) and east (B-5) abutments, respectively. Drilled shaft diameters should be at least 24 inches.

2. The area of the shaft reinforcement, extending from top to bottom, should not be less than 0.5 percent of the gross area of the shaft. Shaft reinforcement may increase after the lateral load analyses are performed.
3. The structural capacities of the shafts should be checked for allowable stresses in the concrete, total downward axial loads, tension forces, lateral forces, and moments produced by dead load plus probable maximum live loads.
4. Maintain a minimum center-to-center spacing between drilled shafts of at least three diameters. If the minimum spacing cannot be maintained, the geotechnical engineer should be retained to consider the group effect of the closely spaced shafts.
5. Vertical movement of the drilled shafts designed and constructed in accordance with these recommendations should be on the order of 1 inch or less, provided that the drilled shaft bearing materials are not significantly disturbed during construction. This estimate is based on the geologic conditions disclosed by the borings, the given loading conditions, and our experience with similar projects.

Straight Sided Drilled Shaft Construction

1. The drilling subcontractor should carefully review the boring logs and be made aware of the presence of the very dense and hard layers, cobbles, boulders, and bedrock at this site. Also, the likelihood that groundwater will be encountered during construction due to the presence of water in the adjacent creek.
2. Contract documents should provide for the use of temporary casings for proper installation of drilled shafts, due to the potential presence of the sandy and/or gravelly soils. A unit price for the use of casing should be identified on the bid tabulation form in the contract documents.
3. All drilled shafts must be drilled dry to allow for inspection of the sidewall and bottom of the drilled shafts. No more than 2 inches of ground water should be in the bottom of the shaft excavation prior to the placement of concrete, if encountered.
4. If casing is used, the head of the concrete must be maintained at a level well above the bottom of the casing. To facilitate casing extraction, the slump of the concrete and the cleanliness of the inside of the casing are critical items that the contractor must control. The top 10 feet of the shaft concrete should be vibrated following placement.

5. To prevent deterioration of the sides and bottoms of shaft excavations, the drilled shaft reinforcement and concrete should be placed the same day drilling operations are completed. Before placement, shafts should be inspected to ensure bottoms and sidewalls are free of deleterious spall and of free water.
6. In order to obtain good shaft-to-soil bonding, it is suggested that drilled shaft concrete be specified as "flowable superplasticized concrete," herein defined as a high slump concrete (7- to 8-inch slump), which still has the proper characteristics of normal concrete such as workability, durability, cohesiveness (will not segregate during placement), and strength.
7. As the design of any foundation relies heavily on generalizations drawn from subsurface conditions determined at a limited number of boring locations, verification of these generalizations at any given location should not be dictated by criteria based on depth or drilling resistance. Instead, the sides and bottoms of shafts should be examined by a representative of the geotechnical engineer of record to assure that shaft bottoms bear in the desired stratum.
8. Drilled-shaft construction should be inspected on a full-time basis by a qualified representative of the geotechnical engineer to (a) verify desired penetration into the bearing stratum, (b) verify shaft dimensions and proper reinforcement, (c) monitor cleanliness and amount of water in shaft excavations, (d) monitor placement of concrete and the use of a tremie or pumps, (e) monitor the extraction of casing, and (f) maintain accurate shaft records (i.e. shaft depths, diameters, and locations).
9. In addition to construction recommendations contained herein, the shafts should be constructed in general accordance with ACI 336.3R, Chapters 4 and 5.

Seismic Site Class

Although borings were not advanced to 100 feet, Site Class D per Table 1613.5.2 of the 2006 International Building Code (IBC) may be used for design of the site structures based on the subsurface conditions encountered at the boring locations.

MULTI-USE PATH

Based on a review of the project plans, the typical multi-use path section will consist of a 6-inch thick concrete path over prepared subgrade. The concrete path width will be 10 feet. Preparation of the subgrade and placement of any fill material beneath the concrete path should be in accordance with the Maricopa Association of Governments Standard Specifications and the following recommendations:

1. Within the pavement area and for a horizontal distance of at least 2 ft beyond the pavement area remove all organics (i.e. roots, trees, grass and other humus), deleterious material and uncontrolled fill material.
2. Scarify at least 6 inches of the cut subgrade and recompact to at least 95 percent of the maximum dry density as determined using ASTM D 698. Hold water contents to within ±2 percent of the optimum water content.
3. All on-site or off-site fill or embankment material required to bring the site pavement areas to grade should be free of organics and deleterious material and generally conform to the following requirements:

Maximum particle size	3 inches
Maximum percent passing #4 sieve	80
Maximum percent passing #200 sieve	40
Maximum plasticity index (PI)	10

4. Fill should be placed in horizontal lifts (compacted lift thickness 6 inches or less) and compacted to at least 95 percent of the maximum dry density as determined by ASTM D 698. Maintain water contents to within ±2 percent of the optimum water content.
5. All utility trench backfill beneath areas to be paved should be compacted to at least 95 percent of the maximum dry density as determined using ASTM D 698. Maintain water contents to within ±2 percent of the optimum water content.

Construction of the rigid pavement should proceed in accordance with the current Maricopa Association of Governments Standard Specifications for Portland Cement Concrete Street Pavement MAG Section 324 and the recommendations presented below. The Portland Cement Concrete shall meet the material specification in MAG Section 725 for Class A concrete.

1. Space transverse and longitudinal contraction joints (induced cracks) at intervals not exceeding 30 times the concrete thickness up to a maximum of 15 feet. The contraction joint pattern should divide the pavement into panels that are approximately square, with the length of any panel no more than 20 percent greater than its width. Depth of joints must be at least one-quarter of the slab thickness. The joints must be saw cut as soon as the concrete has hardened and will not tear or ravel when cut, and not more than 16 hours after placement. Frequent depth checks of the joints is recommended by an independent quality control agency during the saw cutting operation.
2. Provide load transfer at the interface between areas of concrete placed at different times using tied and keyed construction joints. Place construction joints at planned

contraction joint locations (see ACI Manual of Concrete Practice, Part 2, for further guidance).

3. Stage pavement construction such that construction traffic, including concrete trucks, do not travel on newly placed concrete pavement until the concrete achieves at least 75 percent of the design strength, usually 7 days.

It should be noted that control of surface drainage and groundwater is important to the performance and life of pavements. Infiltration of water into the pavement subgrade will result in premature loss of serviceability. Adequate drainage provisions should be included in the pavement design.

EXCAVATION POTENTIAL

Excavation operations along the path will primarily encounter completely weathered granite (soil consisting of sand and gravel with varying amounts of silt and clay) with occasional cobbles and boulders size material. In addition, relatively intact weathered granite may be encountered in areas. The cobbles, boulders and relatively intact granite may impede progress and the ability to cut neat excavations. Due to the fact that most of the borings were advanced with auger drilling procedures it is anticipated that heavy-duty (i.e. Caterpiller D10R) earth moving equipment will be able to excavate the near surface materials on-site. However, contractors should form their own opinion about what equipment will be required to excavate the on site soils and weathered rock.

PERMANENT CUT SLOPES

Responsibility for temporary sloping and/or temporary support for the safety of workers is the sole responsibility of the contractor. The project will include various cut slopes along the multi-use path. All cut slopes should be constructed with a slope of 4 horizontal to 1 vertical or flatter. If a specific slope is steeper than 4 horizontal to 1 vertical it should be analyzed on a case-by-case basis.

SOIL CORROSION POTENTIAL

Steel and concrete elements in contact with soil, whether part of a foundation or part of the supported structure, are subject to degradation due to corrosion or chemical attack. Therefore, buried steel and concrete elements should be designed to resist corrosion and degradation based on accepted practices. General discussions regarding the corrosion of steel and the degradation of concrete with respect to the results of the analytical tests are provided in the following sections of this report.

Corrosion of Steel

Corrosion is a major factor in the life of steel elements in contact with soil. Corrosion is caused by migration of electrons from the steel into the surrounding soil. Three measurable soil properties that indicate the corrosion potential for steel in contact with soil are: 1) soluble chloride, 2) pH, and 3) electrical resistivity. Laboratory pH, resistivity and soluble chloride test results are presented earlier in this report in the "Laboratory Testing" section. It is generally accepted that corrosion of steel is most likely to occur in environments that have chloride ions (even in low concentrations), low pH, and/or low resistivity.

The following table presents some general guidelines concerning the corrosion potential of soil on steel pipe as a function of soluble chloride and electrical resistivity. If the pH is less than 7, the soil is acidic and corrosive conditions are indicated[5].

Soluble Chloride Concentration[6] (ppm)	**Electrical Resistivity[7] (ohm-cm)**	**Corrosion Potential**
> 500	0 –1,000	Very Severe
100 – 500	1,000 – 2,000	Severe
25 – 100	2,000 – 5,000	Moderate
10 – 25	5,000 – 10,000	Mild
-----	10,000 +	Very Mild

Each variable should be used independently of the others when evaluating soil corrosion potential. For example, it is not necessary to have both a resistivity between 0 and 1,000 ohm-cm and a pH less than 7 to indicate a very high corrosion potential.

The pH of the samples tested is above 7, which indicates the soils are not corrosive; the soluble chloride content varies from 310 to 960 ppm, which indicates the soils have a severe to very severe corrosion potential; and the measured resistivity values range from 134 to 736 ohm-cm, which indicates the soils have a very severe corrosion potential. Based on the results of our analyses, the soils at the site appear to exhibit a very severe tendency to corrode buried steel,

5 Johnson Division, UOP Inc., (1975), Ground Water and Wells, Saint Paul, Minnesota, pg. 194.
6 Department of the Navy, Bureau of Yards and Docks, Design Manual, Civil Engineering, NAVDOCKS DM-5, pg. 5-9-53.
7 Palmer, J. F., "Soil Resistivity Measurements and Analysis," *Materials Performance*, Vol. 13, January 1974.

such as underground steel piping. A Corrosion Engineer should review the test results discussed herein when designing appropriate methods of protecting buried steel.

Degradation of Concrete

The degradation of concrete is caused by chemical agents in the soil or groundwater that react with concrete to either dissolve the cement paste or precipitate larger compounds which cause cracking and flaking. The concentration of water-soluble sulfates in the soils is a good indicator of the potential for chemical attack of concrete. The soluble sulfate content in soil can be used to evaluate the need for protection of concrete based on the following table.

Water Soluble Sulfate Content In Soil[8], (percent)	Water Soluble Sulfate Content In Soil, (ppm)	Degradation Potential
> 2.0	> 20,000	Very Severe
0.2 – 2.0	2,000 – 20,000	Severe
0.1 – 0.2	1,000 – 2,000	Moderate
0.0 – 0.1	0 – 1,000	Mild

The soluble sulfate content varies from 93 to 530 ppm, which indicates that the potential for the degradation of concrete is mild at the site.

CONTINUING SERVICE

Two additional elements of geotechnical engineering service are important to the successful completion of this project.

1. Consultation with Design Professionals During The Design Phases. This is important to ensure that the intentions of our recommendations are properly incorporated in the design, and that any changes in the design concept properly consider geotechnical aspects.
2. Observation and Monitoring During Construction. A geotechnical engineer or field technician from our firm should observe the footings excavations and earthwork phases of the work to determine that subsurface conditions are compatible with those used in the analysis and design. During site grading, placement of structural fill should be observed and tested to confirm that the proper density has been achieved.

[8] American Concrete Institute, *ACI Manual of Concrete Practice*, 1998, Part 1, Materials and General Properties of Concrete, Section 201.2R-10.

CONDITIONS

Since some variation was found in subsurface conditions at boring locations, all parties involved should take notice that even more variation may be encountered between boring locations. Statements in the report as to subsurface variation over given areas are intended only as estimations from the data obtained at specific boring locations.

The professional services that form the basis for this report have been performed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers practicing in the same locality. No warranty, expressed or implied, is made as the professional advice set forth.

Fugro's scope of work does not include the investigation, detection, or design related to the presence of any biological pollutants. The term 'biological pollutants' includes, but is not limited to mold, fungi, spores, bacteria, and viruses, and the byproducts of any such biological organisms. The scope of this investigation and report also does not include consideration of hazardous releases or toxic contamination of any type.

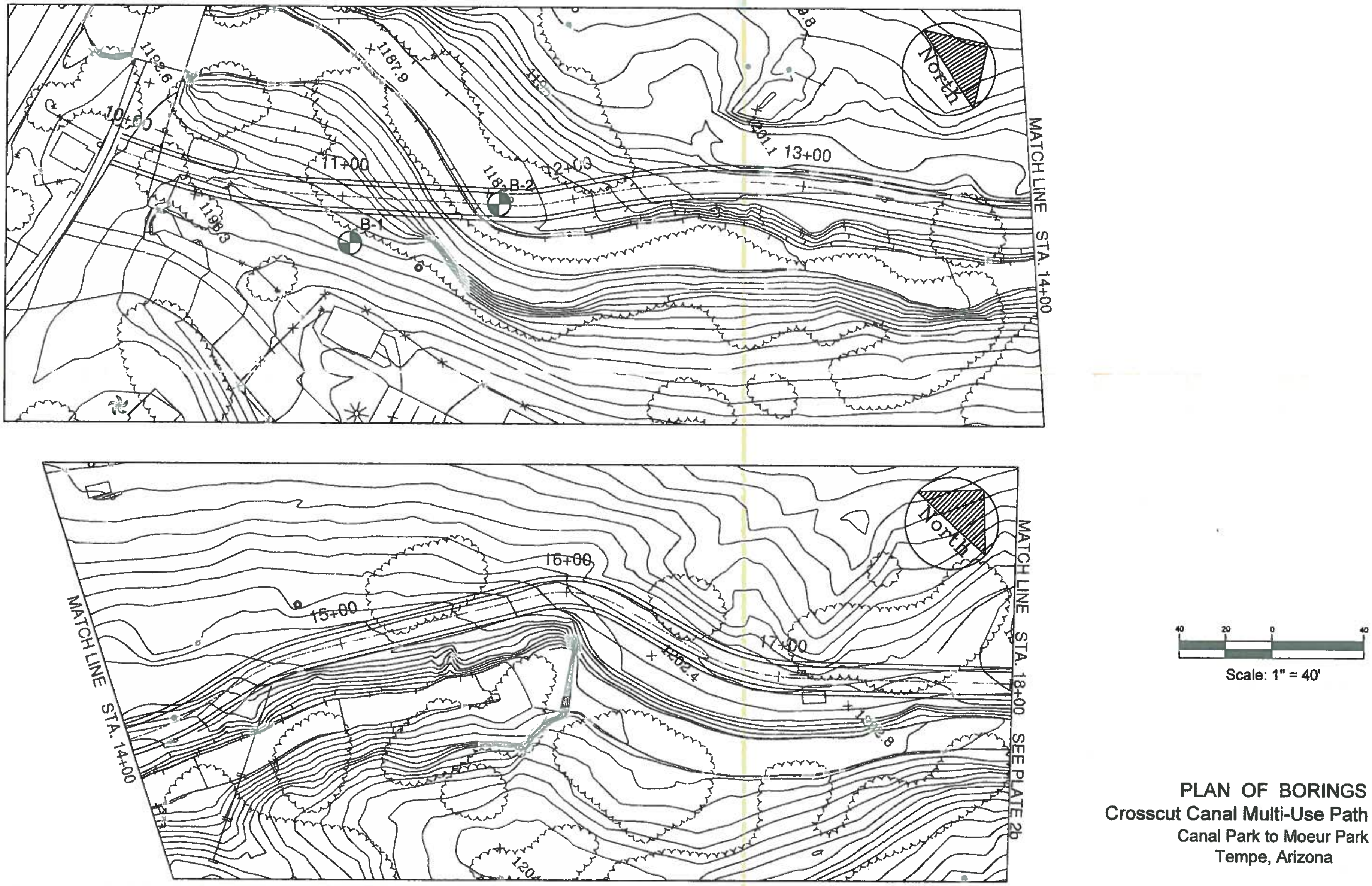
The results, conclusions, and recommendations contained in this report are directed at, and intended to be utilized within, the scope of work contained in the agreement executed by Fugro Consultants, Inc. and client. This report is not intended to be used for any other purposes. Fugro Consultants, Inc. makes no claim or representation concerning any activity or condition falling outside the specified purposes to which this report is directed, said purposes being specifically limited to the scope of work as defined in said agreement. Inquiries as to said scope of work or concerning any activity or condition not specifically contained therein should be directed to Fugro Consultants, Inc. for a determination and, if necessary, further investigation.

PLATES

VICINITY MAP

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

Report No: 3808-1014



PLAN OF BORINGS

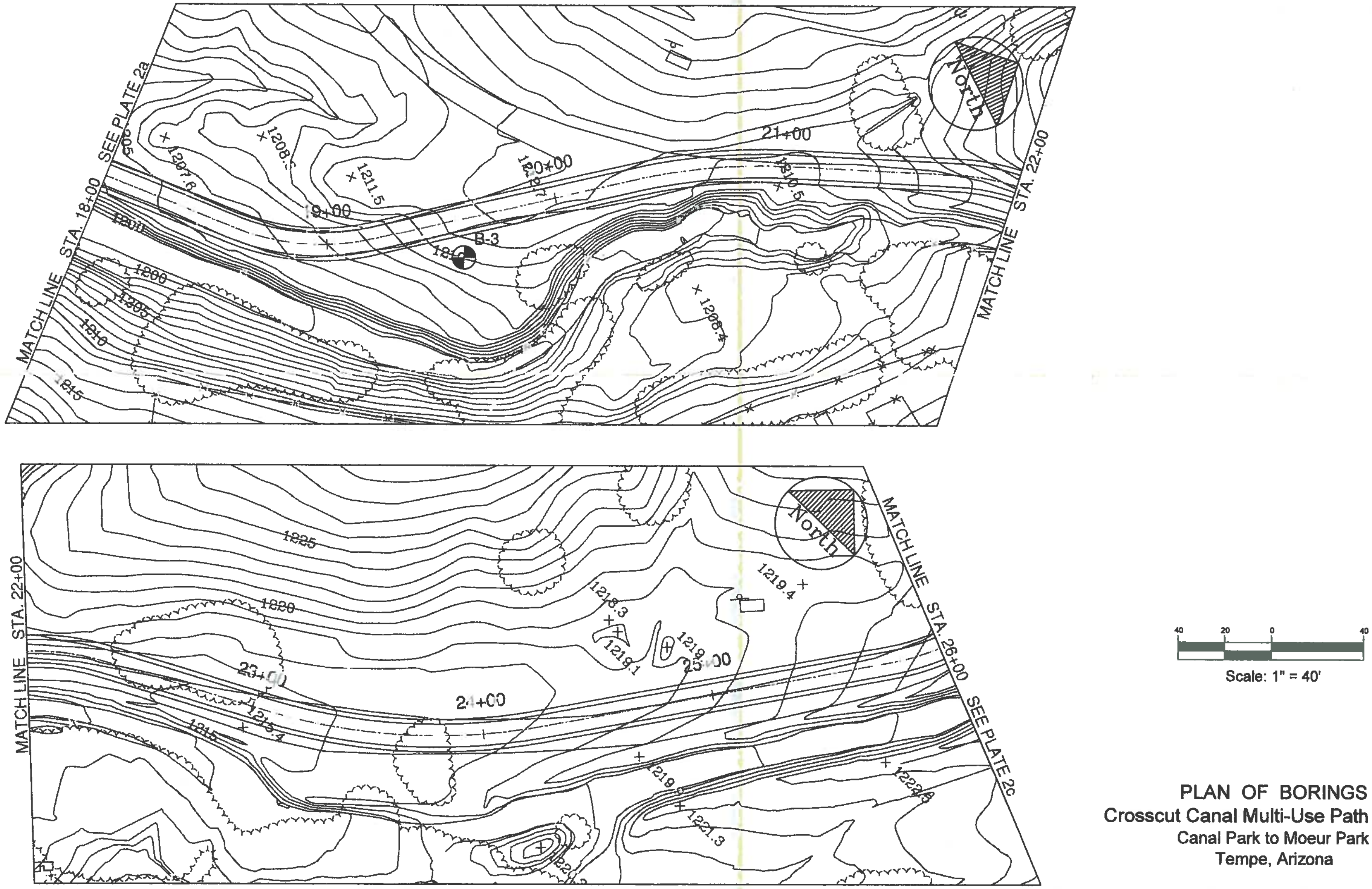
Crosscut Canal Multi-Use Path Phase II

Canal Park to Moeur Park

Tempe, Arizona

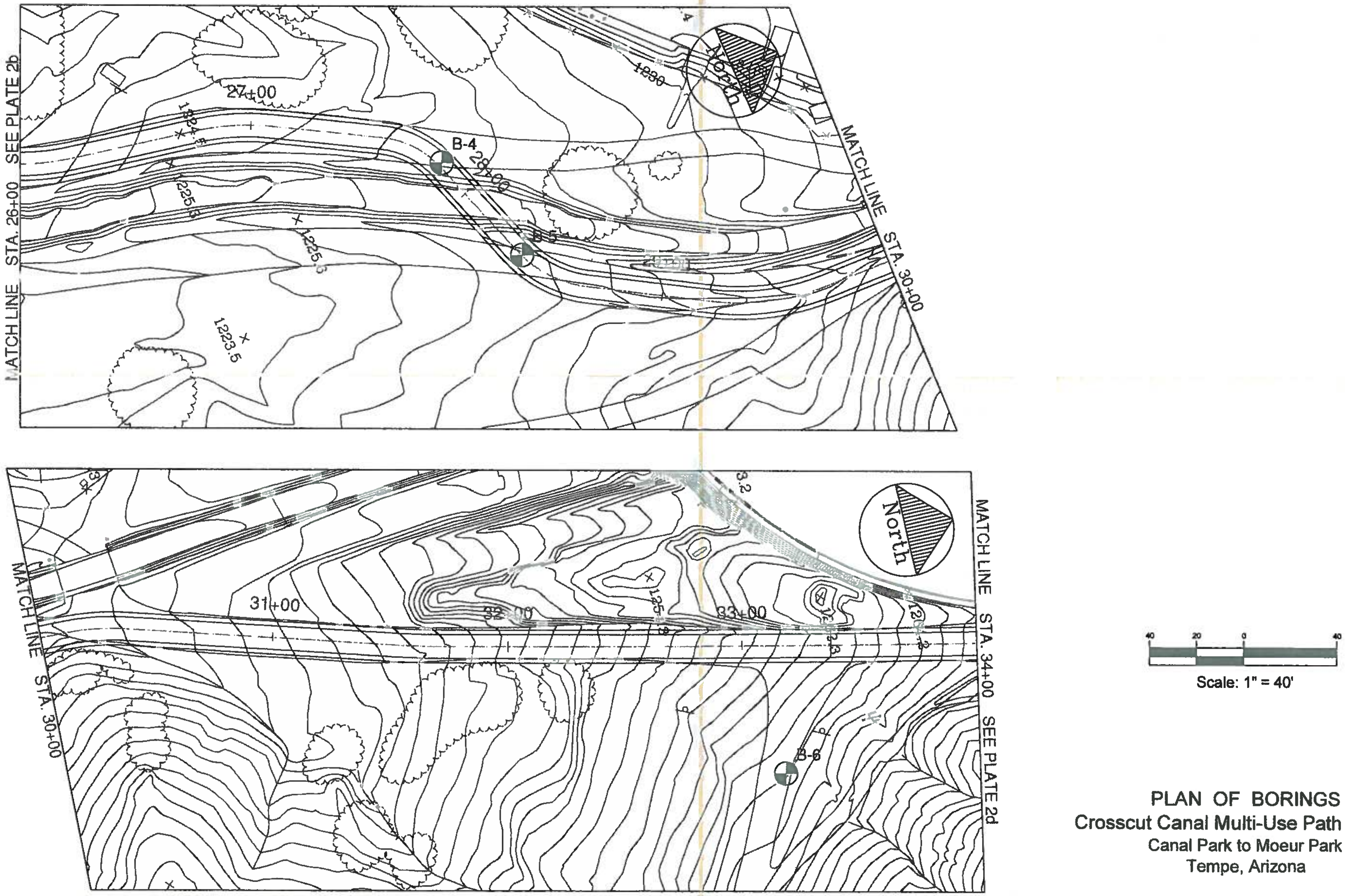
PLATE 2a

Report No: 3808-1014



PLAN OF BORINGS
Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

PLATE 2b



PLAN OF BORINGS
Crosscut Canal Multi-Use Path Phase II
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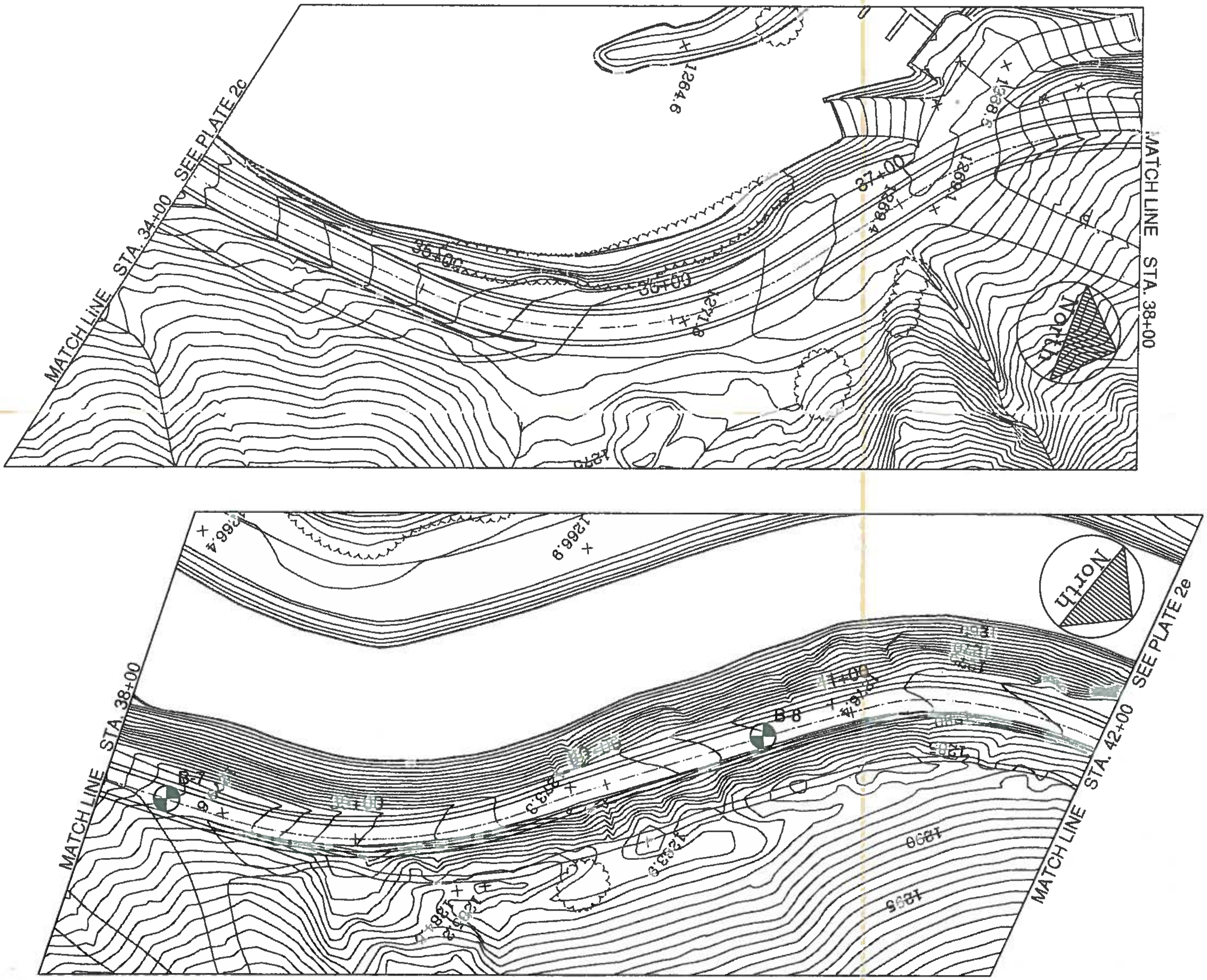
PLATE 2c



PLAN OF BORINGS
Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

PLATE 2d

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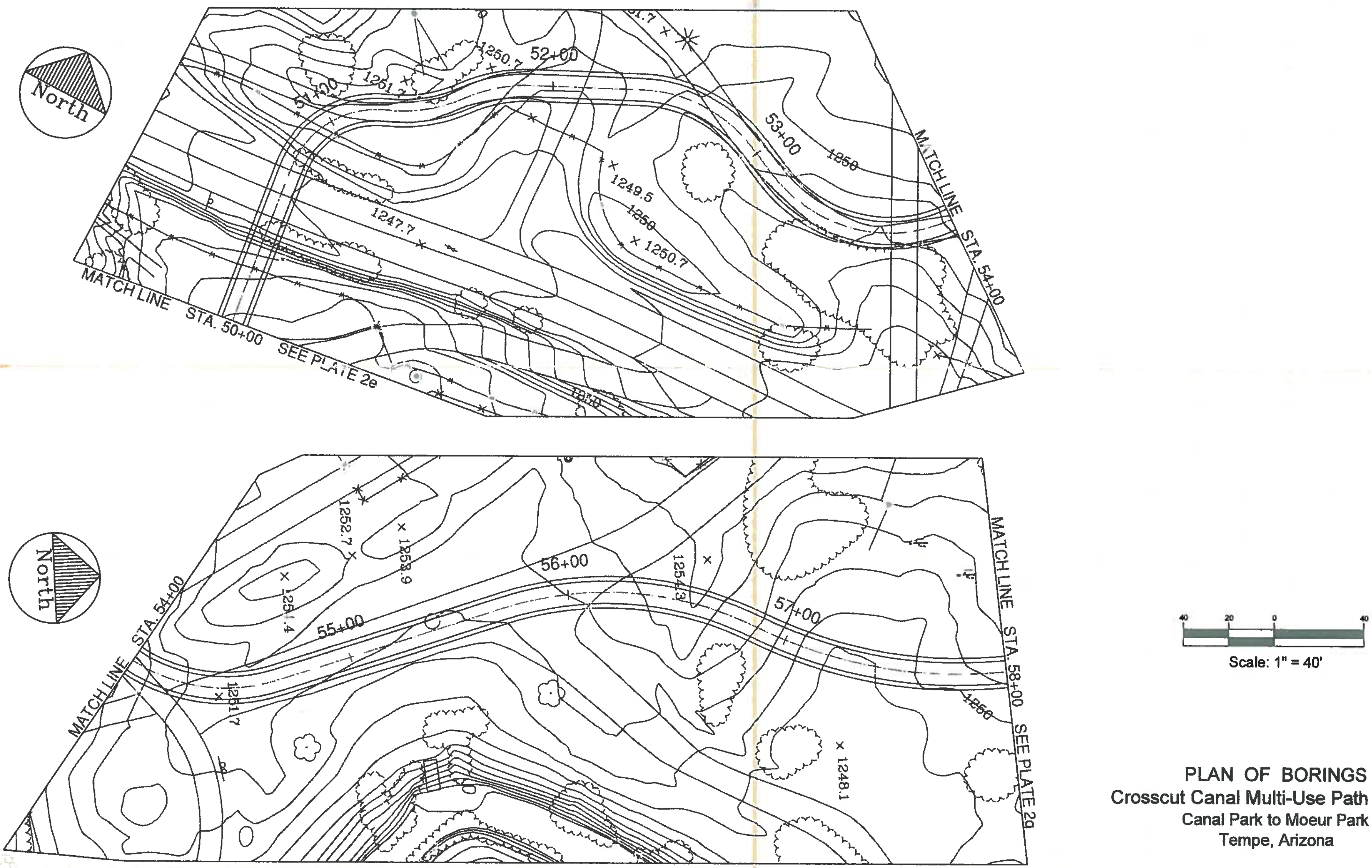
PLAN OF BORINGS
Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

PLATE 2e



PLAN OF BORINGS

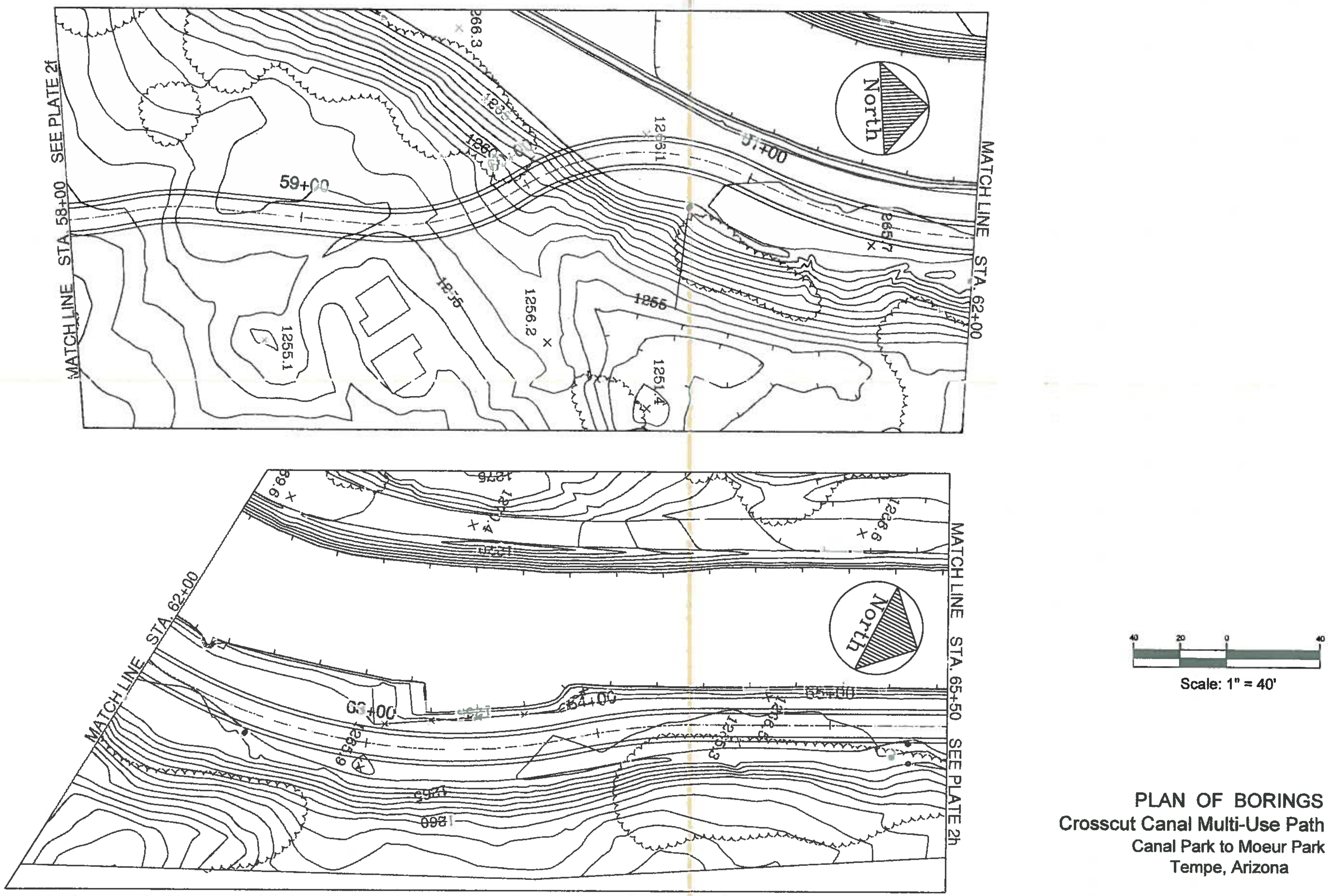
Crosscut Canal Multi-Use Path Phase II

Canal Park to Moeur Park

Tempe, Arizona

PLATE 2f

Report No: 3808-1014



PLAN OF BORINGS
Crosscut Canal Multi-Use Path Phase II
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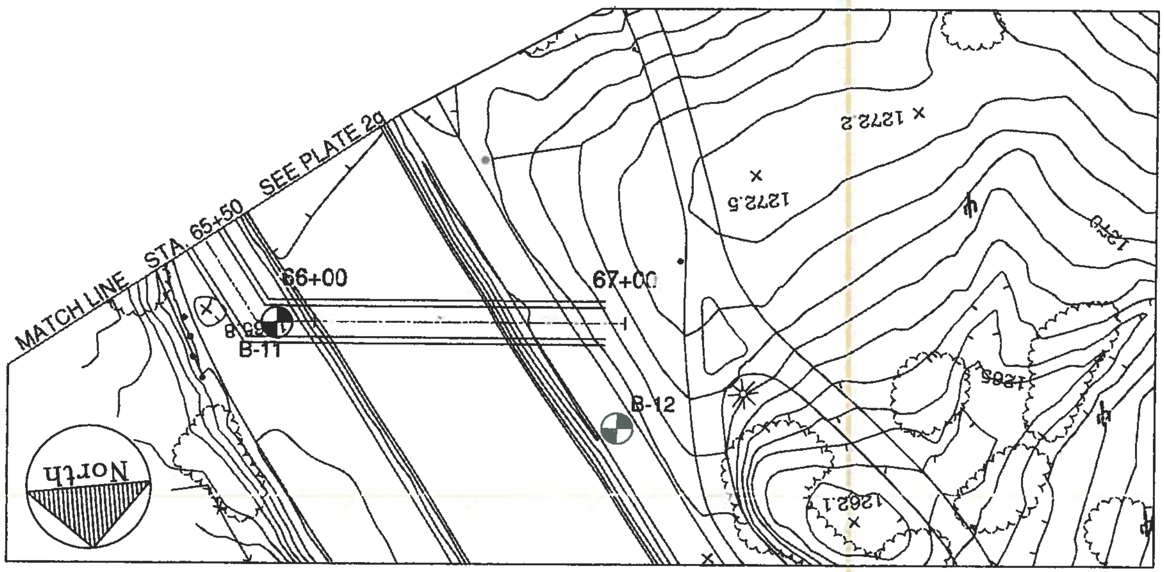
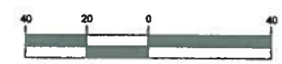
Tempe, Arizona

PLATE 2g





PLAN OF BORINGS
Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

PLATE 2h

LOG OF BORING B-1

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

TYPE: Auger   LOCATION: See Plate 2

SURF. EL. 1195 ±ft   Job No. 3808-1014

DEPTH, FT	BLOWS PER FOOT / %REC (%RQD)	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	DRY DENSITY (pcf)
	12	SILTY SAND WITH GRAVEL (SM), light brown, medium dense to very dense, dry.								
5	75			2	28	23	5	67	21	
	80									
			1186.0 9.0							
10	35 50 50/4"	CLAYEY SAND WITH GRAVEL (SC), light brown, very dense, dry, few to little gravel.		4	41	24	17	71	31	
15	97									
			1177.0 18.0							
20	29 50/4"	SILTY SAND (SM), light brown, very dense, dry, few to little gravel.		5	33	24	9	87	32	
25	50/4"									
30	39 50/5"									
35	50/5"		1159.5 35.5							
40		Coordinates: 33° 26.349' N, 111° 56.601' W								

COMPLETION DEPTH: 35.5 ft   DEPTH TO WATER: No water   DRILL DATE: 12/1/08

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

TYPE: Auger

LOCATION: See Plate 2

SURF. EL. 1187 ±ft   Job No. 3808-1014

DEPTH, FT	BLOWS PER FOOT / %REC (%RQD)	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	DRY DENSITY (pcf)
0–5	16	SILTY SAND WITH GRAVEL (SM), brown, medium dense, dry.		4	NP	NP	NP	71	18	
	29		1182.0 / 5.0							
5–12	55	CLAYEY GRAVEL WITH SAND (GC), brown, very dense, moist.		7	40	24	16	59	23	
	50/5"		1175.0 / 12.0							
12–26	73	SILTY SAND WITH GRAVEL (SM), light brown, very dense, moist.		8	36	26	10	76	24	
	51									
	41 50/3"		1161.0 / 26.0							

Coordinates: 33° 26.359' N, 111° 56.600' W

COMPLETION DEPTH: 26.0 ft   DEPTH TO WATER: No water   DRILL DATE: 12/1/08

LOG OF BORING B-3

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

TYPE: Auger LOCATION: See Plate 2

SURF. EL. 1210 ±ft Job No. 3808-1014

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT / %REC (%RQD)	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	DRY DENSITY (pcf)
			34 50/5"	SILTY SAND WITH GRAVEL (SM), tan, very dense, dry.		4	29	24	5	74	24	
5			50/1"									
			50/5"									
10			50/5"		1199.5 10.5							
15				Coordinates: 33° 26.455' N, 111° 56.508' W								
20												
25												
30												
35												
40												

COMPLETION DEPTH: 10.5 ft DEPTH TO WATER: No water DRILL DATE: 12/1/08

LOG OF BORING B-4

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

TYPE: Auger/Core — LOCATION: See Plate 2

SURF. EL. 1226 ±ft — Job No. 3808-1014

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT / %REC (%RQD)	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	DRY DENSITY (pcf)
			26 50/2"	SILTY SAND WITH GRAVEL (SM), light tan, very dense, dry.	1223.0 3.0	3	20	17	3	80	19	
5			83 (65)	GRANITE, light reddish gray, hard, moderately weathered.								
				- compressive strength at 5 ft = 445 tsf								156
			100 (83)									
				- compressive strength at 8 ft = 177 tsf								153
10												
			100 (78)									
15												
			100 (52)									
20				- compressive strength at 19 ft = 346 tsf								155
					1204.5 21.5							
25				Coordinates: 33° 26.563' N, 111° 56.419' W								
30												
35												
40												

COMPLETION DEPTH: 21.5 ft — DEPTH TO WATER: No water — DRILL DATE: 12/1/08

LOG OF BORING B-5

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

TYPE: Auger/Core

LOCATION: See Plate 2

SURF. EL. 1227 ±ft

Job No. 3808-1014

DEPTH, FT	BLOWS PER FOOT / %REC (%RQD)	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	DRY DENSITY (pcf)
0–10	50/1"	SILTY, CLAYEY GRAVEL WITH SAND (GC-GM), brown, very dense, dry.		5	25	19	6	56	22	
	50/3"									
	50/0"									
	0 (0)		1217.0 / 10.0							
10–20	15 (0)	HIGHLY WEATHERED GRANITE, light reddish gray, moderately hard.								
	25 (0)		1207.0 / 20.0							
20–25	100 (40)	GRANITE, light reddish gray, hard, moderately weathered.								
		- compressive strength at 22 ft = 163 tsf								153
		- compressive strength at 24 ft = 222 tsf	1202.0 / 25.0							155

Coordinates: 33° 26.566' N, 111° 56.408' W

COMPLETION DEPTH: 25.0 ft DEPTH TO WATER: No water DRILL DATE: 12/2/08

LOG OF BORING B-6

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

TYPE: Auger LOCATION: See Plate 2

SURF. EL. 1259 ±ft Job No. 3808-1014

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT / %REC (%RQD)	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	DRY DENSITY (pcf)
			33	POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM), tan and gray, dense to very dense, dry.		3	30	23	7	56	12	
5			50/5"		1253.0 6.0							
			50/3"	CLAYEY SAND WITH GRAVEL (SC), reddish brown, very dense, dry.								
10			50/5"		1248.5 10.5							
15				Coordinates: 33° 26.639' N, 111° 56.365' W								
20												
25												
30												
35												
40												

COMPLETION DEPTH: 10.5 ft DEPTH TO WATER: No water DRILL DATE: 12/2/08

LOG OF BORING B-7

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

TYPE: Auger | LOCATION: See Plate 2

SURF. EL. 1279 ±ft | Job No. 3808-1014

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT / %REC (%RQD)	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	DRY DENSITY (pcf)
			39	CLAYEY GRAVEL WITH SAND (GC), brown, medium dense to very dense, dry.		5	27	19	8	59	22	
5			28									
			50/2"									
10			50/1"		1268.5 10.5							
15				Coordinates: 33° 26.702' N, 111° 56.398' W								
20												
25												
30												
35												
40												

COMPLETION DEPTH: 10.5 ft DEPTH TO WATER: No water DRILL DATE: 12/2/08

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

TYPE: Auger | LOCATION: See Plate 2

SURF. EL. 1276 ±ft | Job No. 3808-1014

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT / %REC (%RQD)	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	DRY DENSITY (pcf)
0–5			50/3"	POORLY GRADED GRAVEL WITH SILT AND SAND (GP), reddish light gray, very dense, dry.		4	27	22	5	49	12	
5			12 50/5"		1271.0 5.0							
10				Coordinates: 33° 26.745' N, 111° 56.441' W								
15												
20												
25												
30												
35												
40												

COMPLETION DEPTH: 5.0 ft | DEPTH TO WATER: No water | DRILL DATE: 12/2/08

LOG OF BORING B-9

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

TYPE: Auger | LOCATION: See Plate 2

SURF. EL. 1277 ±ft | Job No. 3808-1014

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT / %REC (%RQD)	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	DRY DENSITY (pcf)
			37	SILTY, CLAYEY GRAVEL WITH SAND (GC-GM), light brown, dense to very dense, dry.		3	24	20	4	58	21	
5			50/0"	- auger refusal at 4.5 ft	1272.5 4.5							
10				Coordinates: 33° 26.778' N, 111° 56.458' W								
15												
20												
25												
30												
35												
40												

COMPLETION DEPTH: 4.5 ft DEPTH TO WATER: No water DRILL DATE: 12/2/08

LOG OF BORING B-10

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

TYPE: Auger — LOCATION: See Plate 2

SURF. EL. 1259 ±ft — Job No. 3808-1014

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT / %REC (%RQD)	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	DRY DENSITY (pcf)
			50/3"	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM), tan, very dense, dry.		1	22	18	4	57	10	
5			50/0"									
			50/0"									
10			50/1"		1248.5 10.5							
15				Coordinates: 33° 26.827' N, 111° 56.423' W								
20												
25												
30												
35												
40												

COMPLETION DEPTH: 10.5 ft — DEPTH TO WATER: No water — DRILL DATE: 12/2/08

LOG OF BORING B-11

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

TYPE: Auger | LOCATION: See Plate 2

SURF. EL. 1266 ±ft | Job No. 3808-1014

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT / %REC (%RQD)	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	DRY DENSITY (pcf)
0–12			18	CLAYEY GRAVEL WITH SAND (GC), tan, medium dense, dry. (FILL)		3	39	29	10	56	16	
			17									
			30			4	28	18	10	49	19	
			27		1254.0 12.0							
12–18			50/5"	CLAYEY GRAVEL WITH SAND (GC), tan, very dense, dry.	1248.0 18.0							
18–40.5			50/3"	CLAYEY SAND WITH GRAVEL (SC), brown, very dense, moist.								
			49 50/3"			6	33	23	10	85	33	
			50/4"									
			50/2"									
			50/3"		1225.5 40.5							

Coordinates: 33° 27.078' N, 111° 56.410' W

COMPLETION DEPTH: 40.5 ft DEPTH TO WATER: No water DRILL DATE: 12/2/08

LOG OF BORING B-12

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona

TYPE: Auger LOCATION: See Plate 2

SURF. EL. 1267 ±ft Job No. 3808-1014

DEPTH, FT	SYMBOL	SAMPLES	BLOWS PER FOOT / %REC (%RQD)	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX(PI),%	PASSING NO. 4 SIEVE,%	PASSING NO. 200 SIEVE,%	DRY DENSITY (pcf)
			9 17 50/2"	SILTY SAND WITH GRAVEL (SM), light brown, dense to very dense, dry.								
5			68			4	32	25	7	63	19	
			41									
10			26 24 50/5"	- moist below 10 ft		6	31	25	6	72	28	
15			58									
				CLAYEY SAND WITH GRAVEL (SC), brown, very dense, moist.	1249.0 18.0							
20			50/4"			6	30	19	11	62	24	
25			50/3"									
30			50/2"									
35			50/1"									
40			50/0"		1226.5 40.5							
				Coordinates: 33° 27.093' N, 111° 56.438' W								

COMPLETION DEPTH: 40.5 ft DEPTH TO WATER: No water DRILL DATE: 12/3/08

TERMS & SYMBOLS USED ON BORING LOGS FOR SOIL

SOIL TYPES

CH, Fat Clay	SP, Poorly-Graded Sand	GP, Poorly-Graded Gravel
CL, Lean Clay	SC, Clayey Sand	GC, Clayey Gravel
ML, Silt	SM, Silty Sand	GM, Silty Gravel
Fill, Unclassified	SW, Well-Graded Sand	GW, Well-Graded Gravel

SAMPLER TYPES

Seamless Push Tube	Core
Standard Penetration Test	Auger
Ring Sampler	Auger Sample

SOIL GRAIN SIZE

U.S.STANDARD SIEVE

	6"		3"		3/4"		4		10		40		200		
BOULDERS		COBBLES		GRAVEL COARSE		GRAVEL FINE		SAND COARSE		SAND MEDIUM		SAND FINE		SILT	CLAY
	152		76.2		19.1		4.76		2.00		0.420		0.074	0.002	

SOIL GRAIN SIZE IN MILLIMETERS

STRENGTH OF COHESIVE SOILS

CONSISTENCY	UNDRAINED SHEAR STRENGTH Kips Per Sq. Ft.	NUMBER OF BLOWS PER FT., N
Very Soft	Less Than 0.25	<4
Soft	0.25 to 0.50	5-8
Firm	0.50 to 1.00	9-15
Stiff	1.00 to 2.00	16-30
Very Stiff	2.00 to 4.00	31-50
Hard	Greater Than 4.00	>50

DENSITY OF GRANULAR SOILS

NUMBER OF BLOWS PER FT., N	RELATIVE DENSITY
0-4	Very Loose
4-10	Loose
10-30	Medium Dense
30-50	Dense
Over 50	Very Dense

ASTM D 2488 TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

ASTM D 2488 Note 15 Criteria for Describing Percentages of Gravel, Sand and Fines

Description	Criteria
Trace	Particles are present but estimated to be less than 5 %
Few	5 to 10 %
Little	15 to 25 %
Some	30 to 45 %
Mostly	50 to 100 %

ASTM D 2488 Table 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

Criteria for Describing Inclusions

Description	Criteria
Parting	Inclusion <1/8" thick extending through sample
Seam	Inclusion 1/8" to 3" thick extending through sample
Layer	Inclusion >3" thick extending through sample

TERMS & SYMBOLS USED ON BORING LOGS FOR ROCK

ROCK TYPES

GRANITE
DOLOMITE
SANDSTONE
HIGHLY WEATHERED GRANITE
HIGHLY WEATHERED DOLOMITE
SHALE
DOLOMITIC LIMESTONE
LIMESTONE
CLAYSHALE

SAMPLER TYPES

Split Spoon
Core
Standard Penetration Test
Auger
Dames and Moore
Auger Sample

HARDNESS

Friable	- Crumbles under hand pressure
Low Hardness	- Can be carved with a knife
Moderately Hard	- Can be scratched easily with a knife
Hard	- Can be scratched with a knife with difficulty

SOLUTION & VOID CONDITIONS

Void	Interstice; a general term for pore space or other opening in rock.
Cavities	Small solutional concavities.
Vuggy	Containing small cavities, usually lined with a mineral of different composition from that of the surrounding rock.
Vesicular	Containing numerous small, unlined cavities, formed by expansion of gas bubbles or steam during solidification of the rock.
Porous	Containing pore, interstices, or other openings which may or may not interconnect.
Cavernous	Containing cavities or caverns, sometimes quite large. Most frequent in limestones and dolomites.

WEATHERING GRADES OF ROCKMASS

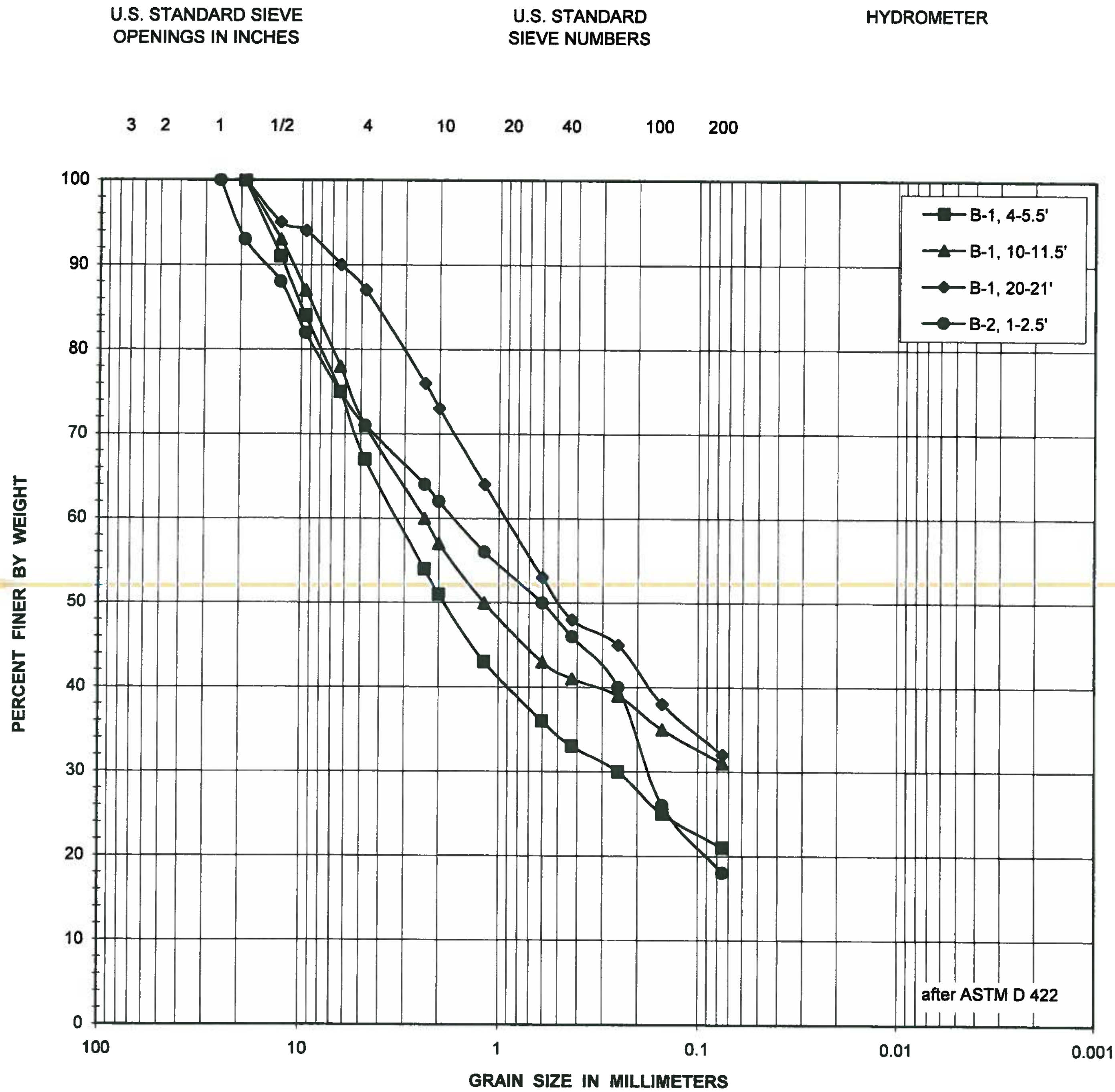
TERM	DESCRIPTION
Slightly	Discoloration indicates weathering of rock material and discontinuity surfaces.
Moderately	Less than half of the rock material is decomposed or disintegrated to a soil
Highly	More than half of the rock material is decomposed or disintegrated to a soil.
Completely	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual Soil	All rock material is converted to soil. The mass structure and material fabric are destroyed.

BEDDING THICKNESS

Very Thick	>4'
Thick	2' - 4'
Thin	2" - 2'
Very Thin	1/2" - 2"
Laminated	0.08" - 1/2"
Thinly-Laminated	<0.08"

JOINT DESCRIPTION

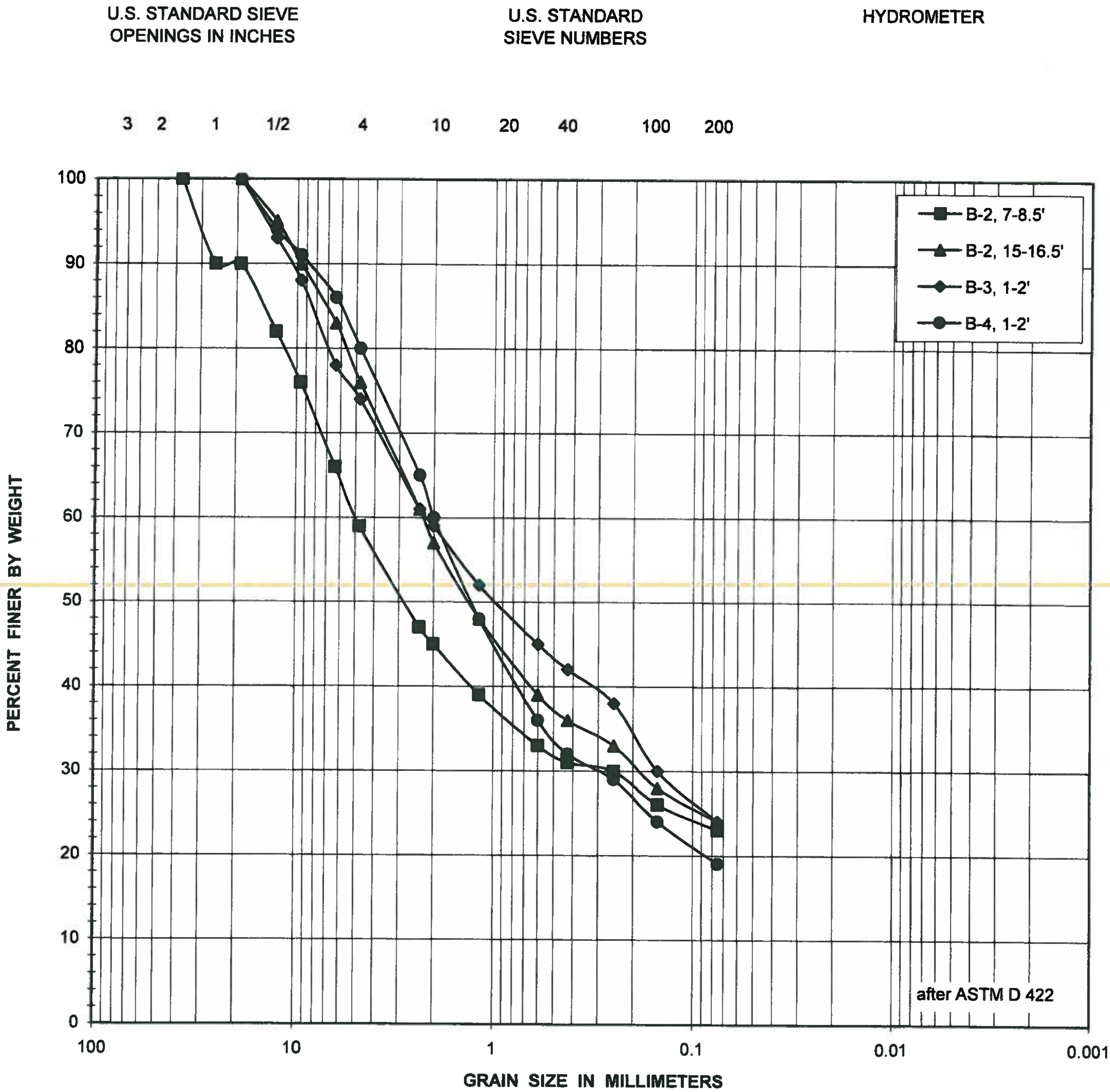
SPACING	INCLINATION	SURFACES
Very Close <2"	Horizontal 0 - 5	Slickensided - Polished, grooved
Close 2" - 12"	Shallow 5 - 35	Smooth - Planar
Medium Close 12" - 3'	Moderate 35 - 65	Irregular - Undulating or granular
Wide >3'	Steeply 65 - 85	Rough - Jagged or pitted
	Vertical 85 - 90	



GRAVEL		SAND			SILT and CLAY
Coarse	Fine	Coarse	Medium	Fine	

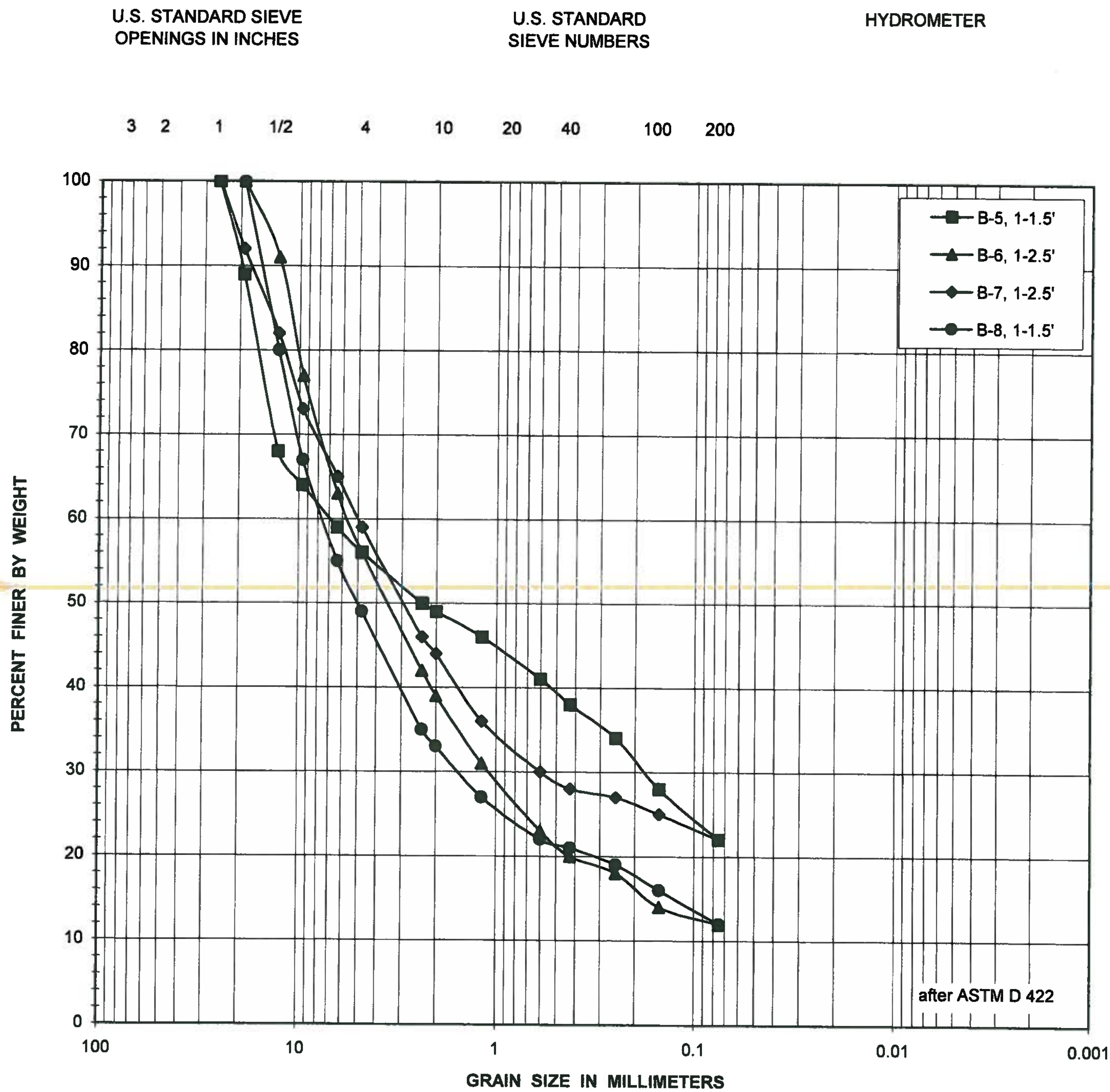
GRAIN SIZE DISTRIBUTION CURVES

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona



GRAVEL		SAND			SILT and CLAY
Coarse	Fine	Coarse	Medium	Fine	

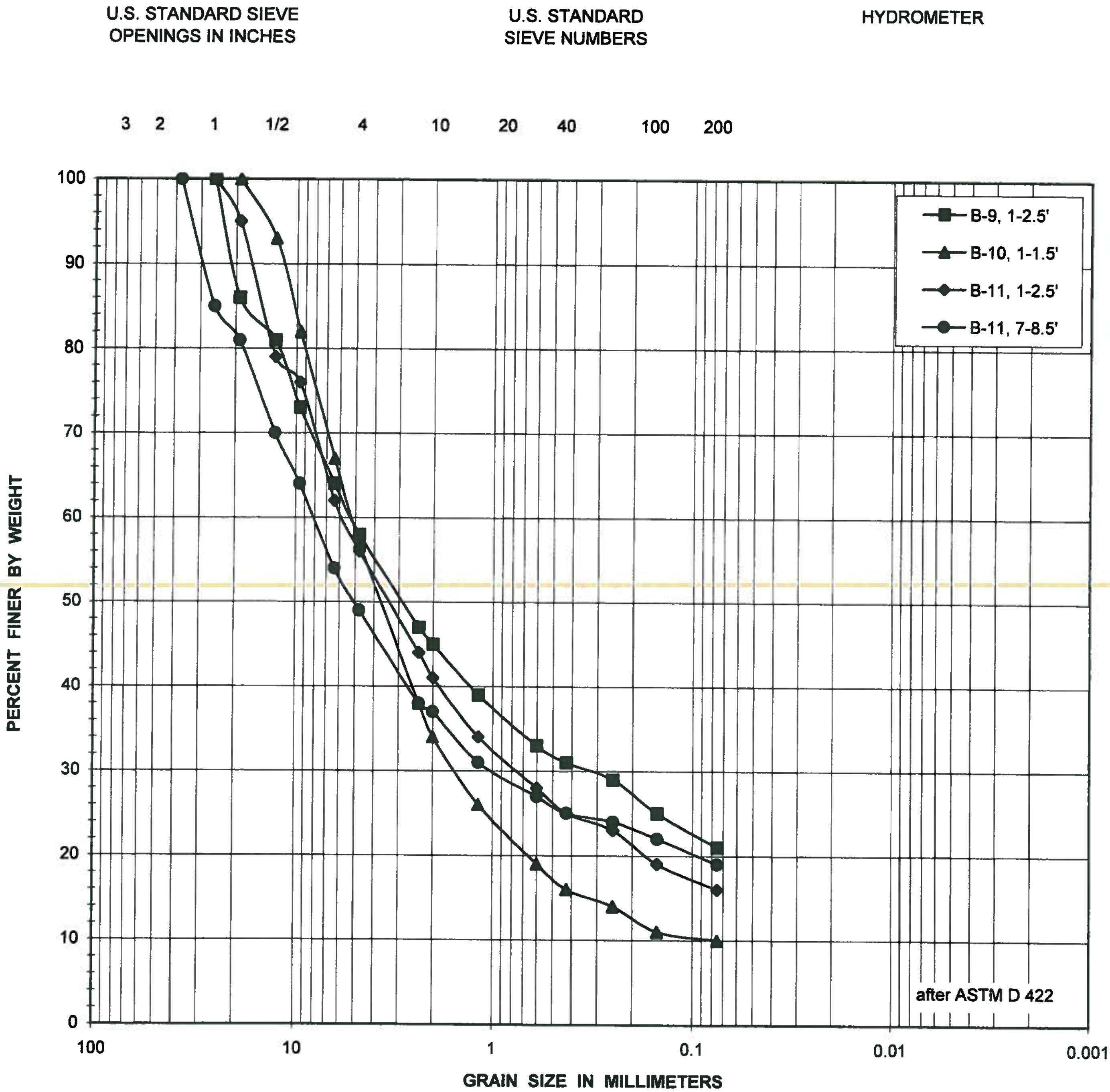
GRAIN SIZE DISTRIBUTION CURVES
Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona



GRAVEL		SAND			SILT and CLAY
Coarse	Fine	Coarse	Medium	Fine	

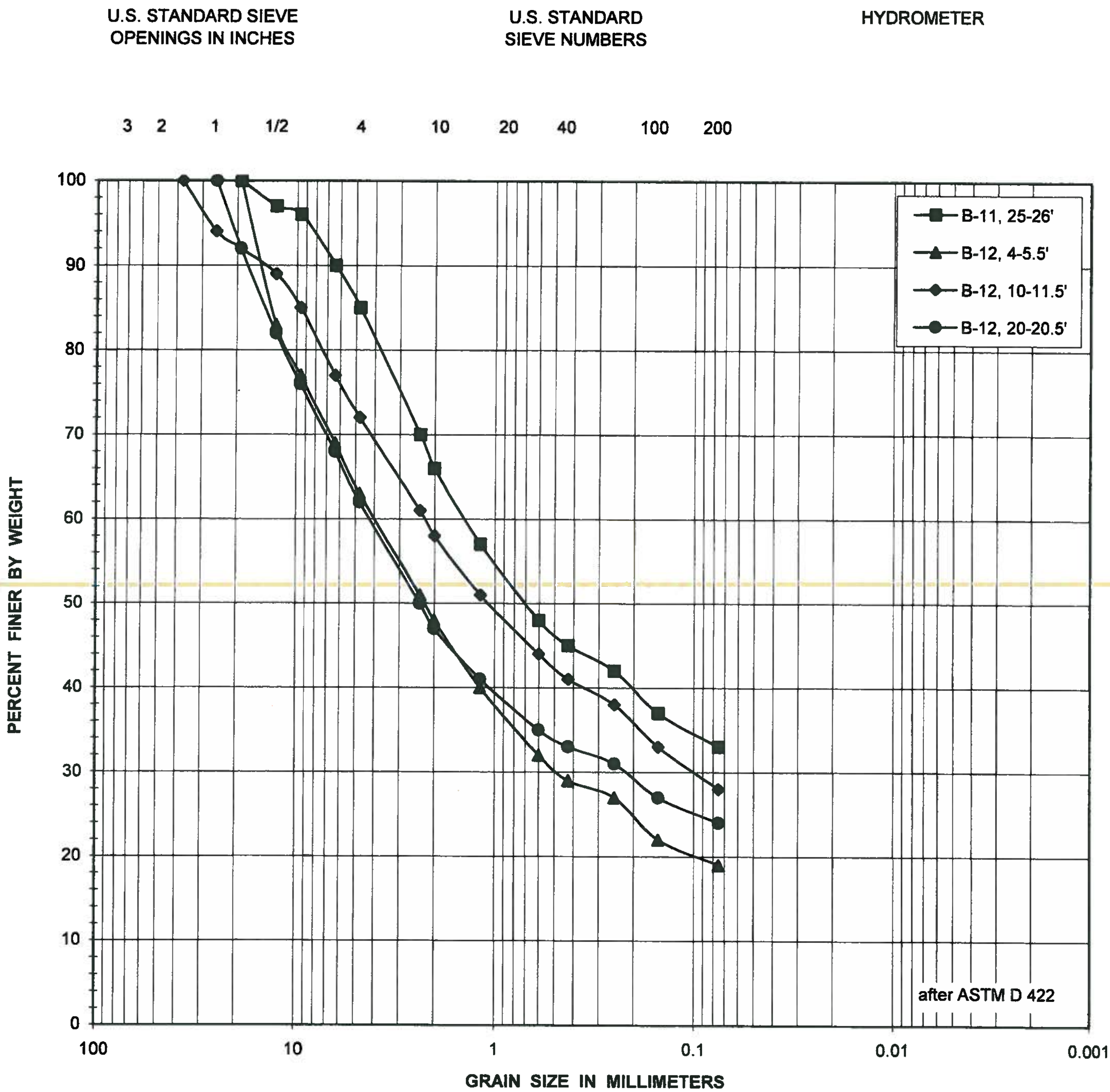
GRAIN SIZE DISTRIBUTION CURVES

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona



GRAVEL		SAND			SILT and CLAY
Coarse	Fine	Coarse	Medium	Fine	

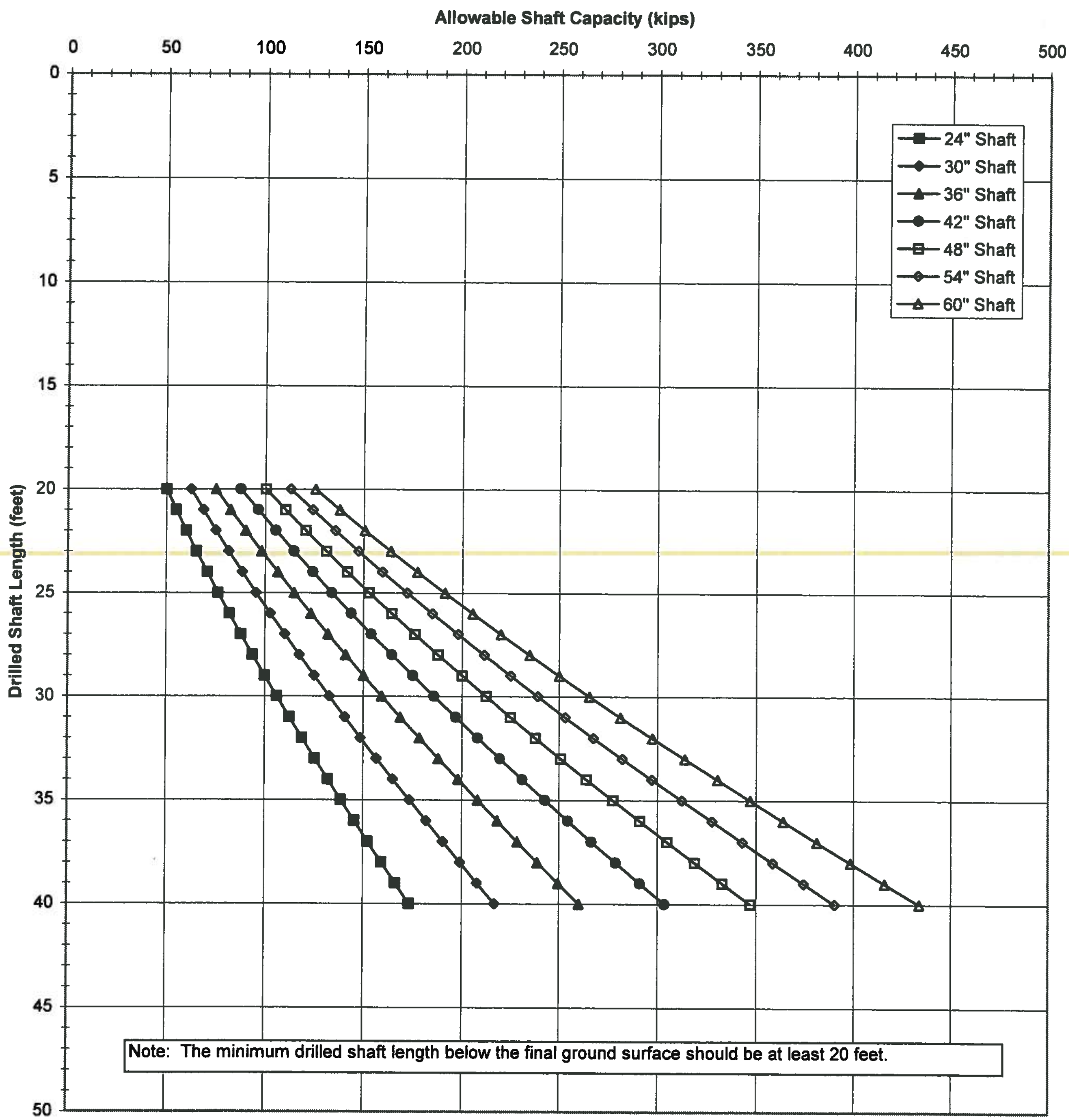
GRAIN SIZE DISTRIBUTION CURVES
Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona



GRAVEL		SAND			SILT and CLAY
Coarse	Fine	Coarse	Medium	Fine	

GRAIN SIZE DISTRIBUTION CURVES

Crosscut Canal Multi-Use Path Phase II
Canal Park to Moeur Park
Tempe, Arizona



ALLOWABLE CAPACITY FOR SINGLE DRILLED SHAFTS

North and South Bridges

Cross-Cut Canal Multi-Use Path Phase II

Canal Park to Moeur Park

Tempe, Arizona